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BLACKSMITH SHOP PRACTICE

ARRANGEMENT AND EQUIPMENT—FORGING OF HOOKS AND CHAINS WELDING

SECOND EDITION

MACHINERY'S REFERENCE BOOK NO. 61
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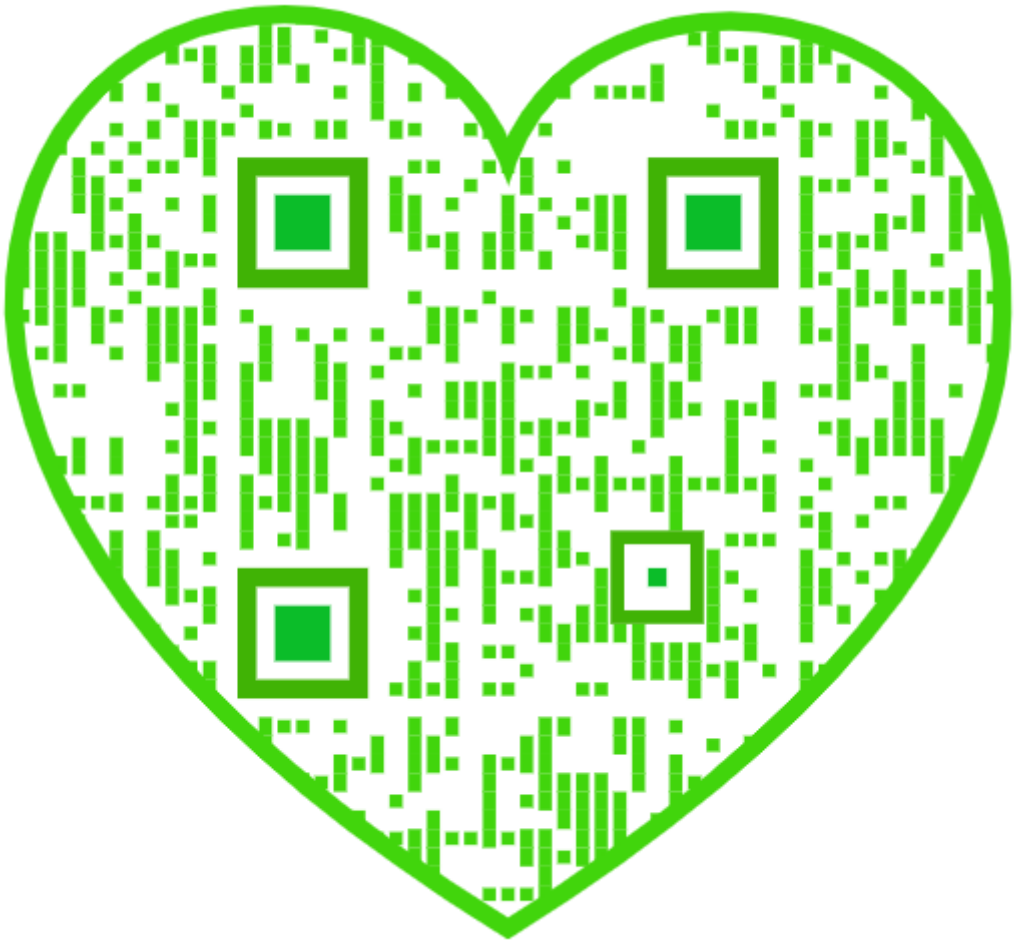

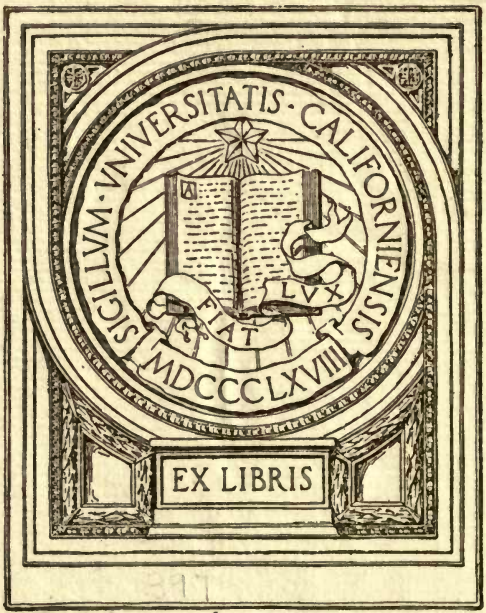
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NUMBER 61

BLACKSMITH SHOP PRACTICE

SECOND EDITION

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CHAPTER 1

ARRANGEMENT AND EQUIPMENT OF A MODEL BLACKSMITH SHOP*

Buildings for manufacturing purposes are as a rule constructed more or less in accordance with recognized standards that have been adopted on account of their adaptability for the particular class of work they are to be used for. In plants of the larger machine-building concerns and similar industries usually all buildings are of the same general style throughout with the exception of the blacksmith or forge shop, which is often entirely different. Why this should be, no good reason is apparent from a practical point of view, as the style adopted is often less suitable for the purpose than that of the other buildings, and the result is that very often blacksmiths and forge men have of necessity to work under conditions that are anything but an incentive to the best results. Workmen, no matter what the nature of their occupation may be, will do more and better work under pleasant and attractive conditions than they can be expected to do in a gloomy atmosphere. In this respect blacksmiths are no exception to the rule. As their art is indispensable to all other industries, a few practical suggestions that would have a tendency, if adopted, to reduce cost, increase and improve production for the employer, and bring about better conditions for the blacksmith, may not be out of place.

The principal essentials of a blacksmith shop where maximum production at minimum cost is expected, are light, ventilation, sanitary arrangements and sufficient space to accommodate a full equipment of machinery and appliances systematically arranged and installed. What the writer considers a basis that could be worked from in constructing, equipping and arranging blacksmith shops from a few forges capacity to the largest is shown and described in the following.

Foundations and Walls

To begin with, the foundation has first to be considered. Where a rock bottom can be had very little preparation for building is necessary, but where building has to be done upon sand, clay or swampy ground it is important that the foundation be made thoroughly solid, otherwise the jar from steam hammers and other machinery will have a tendency to warp and crack the walls. The construction, in general, like that of buildings for other purposes, should be governed to a certain extent by the class, size and weight of the work that has to be done. If used for light forging exclusively, the walls need neither be as high nor as heavy as where the work is varied or of large proportions. For light and medium weight work walls need not be more than from 15 to 20 feet in height, but for heavy work or where it is of a wide variety as in railroad or heavy machine building shops, the walls should be

* MACHINERY, October, 1909.

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from 20 to 25 feet in height so that there would be sufficient space between the tops of large steam hammers and the roof trusses for the free use of jib cranes or other overhead lifting and conveying devices.

Very little can be said specifically regarding the foundation, as general conditions and the nature of the site would have to be taken into account before any authentic information could be given, other than that it should be made as solid as possible. The walls, preferably of brick or reinforced concrete, should be of a more substantial nature than is generally required for other purposes. The piers between windows may be supported either with pilasters or buttresses or a combination of both. For the admission of plenty of fresh air which is essential in all manufacturing buildings, especially in blacksmith shops where more or less heat is radiated from forges and furnaces, the windows should not be over 36 inches above the level of the floor. If placed higher in the walls, which is often done to save their being broken by flying pieces of iron or steel, or to conform with a pet theory of protecting the men employed from drafts, they are too high to be of much benefit other than admitting light, as the greater portion of the air admitted enters at a point too high to benefit the workmen or to keep the lower portion of the shop where heat is generated cool enough to be comfortable. Plain sash windows that can be raised from the bottom and lowered from the top are the best type to use and can be protected inside and out with wire screen. In locating doors it is well to have one in each end of the building large enough for the admittance or removal of any kind of work or material, and to have others in the side walls where they may be required.

Forge Space and Arrangement

The next thing that calls for attention is the amount of space that is necessary for each forge. This depends very much upon their arrangement. If they are grouped as is customary in some shops, a saving of space is effected, but work in general cannot be so conveniently or economically handled as when they are arranged in rows, for the reason that in groups men from some of the forges will either have to pass between other men and their forges or anvils or take a long roundabout way to and from steam hammers; not only this, but work is often of a shape that can only be handled to advantage on forges with at least three sides accessible. It is therefore advisable that they be arranged in rows at a sufficient distance from the walls to allow of portable vise benches, surface plates, etc., being used where the light is best, and moved from place to place as they are required, without necessarily taking them into the center of the floor or between blacksmiths and steam hammers. With forges installed from 5 to 6 feet from the walls and 16 feet of space allowed for each as shown in the plan view on pages 20 and 21, there would just be sufficient space around them for the tools generally used at the anvil and the convenient handling of all ordinary blacksmith work. For light work they may be placed a little closer than 16 feet, but more difficulty is experienced in trying to do work in limited space than where there is

sufficient room. Wherever conditions will permit, it is preferable to have blacksmith shops, if they exceed the capacity of 10 forges, wide enough for a row on each side with corresponding rows of steam and power hammers facing the forges on the side of the shop in which they are installed.

Forges used for the average range of blacksmithing are from 36 to 48 inches in width. With these placed 5 feet from the walls and anvils from 18 to 24 inches out from the line of forges, the distance from wall to anvil will be approximately 11 feet. At least 12 feet of clear space should be allowed between the line of anvils and steam or belt-driven hammers, the bases of which are anywhere from 5½ to 8 feet in length. As a certain amount of space behind the hammers is necessary, 10 feet more may be added. Thus a shop of approximately 40 feet in width is required for single rows of forges and hammers and 80 feet for double rows. The advantages of a short wide shop over a long narrow one are obvious. It is more compact and better under the observation of the man in charge. The space back of the steam hammers is doubled, making the center of the shop wide enough for a line of car tracks which may be standard or narrow gage, and for the handling of work too long or of a shape that could not be advantageously handled by ordinary means. Not only this, but the saving in actual construction, which would amount to about one-third, is an item too important to be overlooked.

There are, however, certain elements to be contended with in the construction of a wide building that can be entirely dispensed with in a narrow one. When a building exceeds a certain width some supports for the roof other than the walls are necessary if cost, which is a prime factor, is to be kept at the lowest margin. These roof supports are generally in the form of columns so arranged that the weight is evenly divided. In blacksmith shops columns or supports should be located where they would offer the least obstruction to the handling of work which is almost invariably hot, and the success of the various operations of shaping it depends upon reaching a steam hammer in the least possible time after it is removed from the fire. It is therefore obvious that the fewer obstructions that are to be avoided, the greater the probability of the work being successfully accomplished. Just behind the line of steam hammers, columns would be entirely out of the way, and would serve the double purpose of supporting the roof and traveling cranes or trolleys.

The points considered and the provision for the storing of bar stock, coal and other materials used in blacksmithing in the same building or adjacent to it, constitute the most important features of an ideal blacksmith shop, which may be constructed, laid out and arranged as indicated in the following, the general outline given being used as a basis to work from.

The general arrangements of a shop of 18 forges in which provision has been made for a full equipment of appliances generally used in a shop of that capacity are shown in the illustrations on pages 20 and 21. One end is assigned to material, as bar stock, coal, etc., and space for

cutting-off and centering machines, in short all that is required for putting work in proper condition to be turned over to the machine shop without workmen having of necessity to go outside the building. Forges are arranged in rows 5 feet from the side walls, with those intended for the largest and heaviest work nearest to the stock supply for which one end of the building is exclusively assigned. All forges are served by an overhead trolley system, one cross-section of which is assigned to each forge for lifting and supporting work at the anvil. Forges for the larger work are further supplied with jib cranes so arranged that the column is well out of the way of the work, so that it can be used for conveying to and supporting at the steam hammer the work of two forges, the furnace being located near the hammer that it serves.

Arrangement of Steam- and Belt-driven Hammers

All power hammers, steam and belt-driven, with the exception of one, which will be referred to later, are installed in rows facing the forges at a distance of 12 feet from the line of anvils, which is just sufficient space for the general range of blacksmith work being done at steam hammers without conflicting with that being done at forges. The steam hammer *A* which is reversed and out of alignment with other hammers can be used for such work as welding long shafts, lead-screws for long lathes, locomotive frames or any other work too long or of a shape that could not be advantageously handled by ordinary means. This class of work is supported by hooks from an overhead trolley and heated in a portable forge so arranged that it drops clear of the work when it is ready to be conveyed to the hammer by turning a lever. This forge is shown and described in the next chapter in connection with the treatment on welding. No definite information can be given upon the number of steam or power hammers necessary for any given number of forges, as that would depend very much upon the class of work to be done. Sometimes three or more blacksmiths could use the same hammer to block out their work without wasting time in waiting for turns, or one man's work conflicting with another's, while on other kinds of work one man may monopolize one hammer for a time. In any case the equipment of hammers and other power appliances should be ample for the requirements, otherwise much time may be wasted in men having to wait after their stock is heated before they can have access to a hammer, or in having to leave it before an operation is completed. In a shop of 18 forges where work is of a wide variety of shape and size, from 6 to 9 hammers will be required. Generally a great part of machine blacksmithing, especially blocking out, can be much more economically heated in furnaces than is possible when forges are used exclusively. It is therefore advisable to use furnaces for all work that can be heated in them, and have them as near to steam hammers as is practicable. In most of the blacksmith shops connected with manufacturing plants one or more toolsmiths are employed, and more or less carbonizing, heat treating, annealing, hardening and tempering has to be done. This class of work should be as

much concentrated as possible, located in the shop where it would be least likely to conflict with other work and be under the charge of a sub-foreman. Saws, shears, cutting-off, straightening and centering machines, together with any other machine tools that may be used, should be located near the stock supply and if possible near the point from which finished work is forwarded to the various departments where it is wanted. These machines and all bar stock would constitute a department that could be attended to by a sub-foreman.

Location of Blowers, Conduits and Piping

The blower for supplying forges and furnaces with blast and the fan for mechanical draft, if a down-draft system of carrying off smoke and gases is to be used, may be installed as near to each other as is practicable and operated by the same motive power, preferably motor drive. Common practice is to elevate blowers and fans above the level of forges; sometimes they are placed upon a platform in the roof trusses to save floor space. This practice is not to be commended for the reason that when the wind gate of a forge or furnace happens to be left open when the blower is closed, gas generated by the still ignited fuel upon the forge enters the pipes and naturally rises. It may escape through the blower unless it happens to be started up before the fire upon the forge has died out. When this happens the gas is forced back upon the still burning fuel where it is ignited, causing an explosion which may ruin pipes and damage the blower. If blowers and fans are installed in a pit below the level of the floor, they are more accessible and the danger of being damaged by explosions is minimized from the fact that gas will not descend except when forced. Generally blast is conducted from the blower to forges and furnaces through a main pipe which is reduced in size as it passes the various branch pipes which connect with the forges. This has a tendency to make the pressure greatest near the terminal of the main pipe. To equalize the blast pressure at all points the main pipe should be in the shape of a loop, both sides of which may be of equal capacity to the discharge of the blower so that it would act as a reservoir permitting of branch pipes being connected with it at right angles instead of the more acute angles generally used, and should it be necessary to increase the blowing facilities or enlarge the capacity of the shop this could be done without changing the blast pipe. In an ideal blacksmith shop all piping should be where it is least likely to be in the way and still be accessible. For this purpose an underground conduit is provided in the shape of a loop directly under the line of forges as shown by dotted lines in the plan view on pages 20 and 21 and also in the cross-section below, of a size sufficient to accommodate the entire piping system including blast, steam, water, gas, oil, compressed air, heat for warming the shop in cold weather, smoke, sewer or any other piping or wiring that may be necessary, and to which access may be had through openings in the floor between forges. These openings should be lined with concrete covered with slatted platforms upon which blacksmiths could stand at their

work and through which heat could be admitted in cold weather and cool air in warm weather either through the heating system or openings in the walls fitted with gratings and shutters that could be opened and closed at will. The water supply which is essential in all blacksmith shops is more important than is generally supposed; each forge ought to be provided with a slake tub, the water in which should be kept fresh. If this has to be carried from a general supply pipe as is customary in most shops, much time is wasted both in emptying and refilling the tubs, that could be turned to good account if a faucet and sewer connection were located near each forge and elsewhere about the shop where they may be required. These connections should not be made directly with the tubs, except at forges used by tool-smiths or where hardening has to be done, as it is often necessary to move tubs and other appliances at forges used for regular forging to make room for work of unusual shape.

Furnaces, Tool Racks, Hammer Foundations and Piping

Furnaces to be used for heating work that is to be blocked to shape in quantities at steam hammers and those used for heating material to be drop-forged or shaped in forging machines, bolt-headers or bull-dozers, may be heated either with solid fuel or oil. Oil is preferable for several reasons. It is conducted from the supply tank to where it is to be used automatically through pipes. Once ignited the supply can be regulated and the heat maintained at an even temperature for any length of time. There is practically no refuse to be removed and no time is wasted in waiting for a fresh supply of fuel reaching the proper temperature for the work to be done as is the case with any kind of solid fuel. For each steam and power hammer there should be a tool rack, preferably portable, of which Fig. 1 is an example, that would accommodate a full set of spring swages, fullers, breaking-down tools, hacks, bolsters or any other appliances that may be used in connection with hammers, each tool as far as possible being assigned to its own place upon the rack. This would overcome the disadvantage of having to turn over a miscellaneous heap of tools usually stacked upon the floor to find the one that is wanted and to move them individually should the space they occupy be temporarily wanted for some other purpose.

To get the greatest efficiency from steam power hammers the foundations upon which they are mounted must be solid. Concrete resting upon hard pan has given better results than the combination of heavy wooden beams and concrete commonly used. In installing solid concrete foundations there should be several inches of cement placed over the concrete and a cushion of wood at least three inches in thickness placed between the cement and the base of the anvil to give the necessary resiliency and prevent the concrete being pulverized by the impact of the blows. Back and front of the hammers there should be openings down to the level of the anvil base so that it could be leveled or adjusted by wedging up and grouting with cement if for any reason it should get sagged or out of alignment with the upper parts of the

hammer. These openings should be covered with hatches level with the floor.

By conducting steam to hammers from the main steam pipes in the underground conduit through branch pipes provided with traps, the disadvantages and annoyance caused by condensation are practically obviated, providing the supply pipes are enclosed in non-conductive casing until they are connected with cylinders. The exhaust and all other pipes leading from hammers may be accommodated in the same casing down to the floor level, where they may be conducted outside the building through conduits and allowed to discharge in the usual manner or be turned into a condenser and ultimately into the sewer.

Foreman's Office, Wash Room, Lockers, etc.

The foreman's office and the room used for special tools, fixtures, formers, welding compounds, etc., should be connected, if possible, and located centrally in a position from which the whole or the greater part of the shop could be easily seen and if possible near the door that is used the most. If that happened to be a side door, office and tool-room may be as shown in the plan view on pages 20 and 21. Should an end door be more convenient the office and tool-room may occupy the space assigned to forge No. 8. For convenience as well as economy, blacksmith shops should be provided with washing accommodation, locker rooms and lavatories, which would not only add to the comfort of the men employed, but would be the means of saving the time that is wasted in going to other buildings. In a shop of 18 forges there should be locker and washing accommodations for at least 60 men. This at a conservative estimate would occupy at least 650 square feet of floor space. The lavatory for obvious reasons should be separate from the locker and washroom, but in close proximity, and is therefore shown in the floor plan just beyond the partition that separates the shop from the coal storage.

Flooring

There is much difference of opinion as to the material that is best adapted for the flooring of blacksmith shops. Wood is too inflammable, bricks crack and break from the heat and impact of work being laid upon them, cement or concrete is poorly adapted for the same reason, and asphalt is out of the question. Nothing that has been tried so far has given better satisfaction or can be installed at less cost than dirt mixed with ashes. If kept moist by being watered at least once every day it is more comfortable to stand upon than anything else that can be used for the purpose. It is easily repaired and leveled should holes or irregularities get worn in it, and it is not affected in the least by hot or heavy pieces of work or material being dropped or laid upon it. The space between walls and forges, however, may be covered with concrete and cement to facilitate the handling of such appliances as portable surface-plates and vises, and the floor of wash-rooms and lavatories may be of asphalt, while that of the foreman's office and tool-room may be of wood.

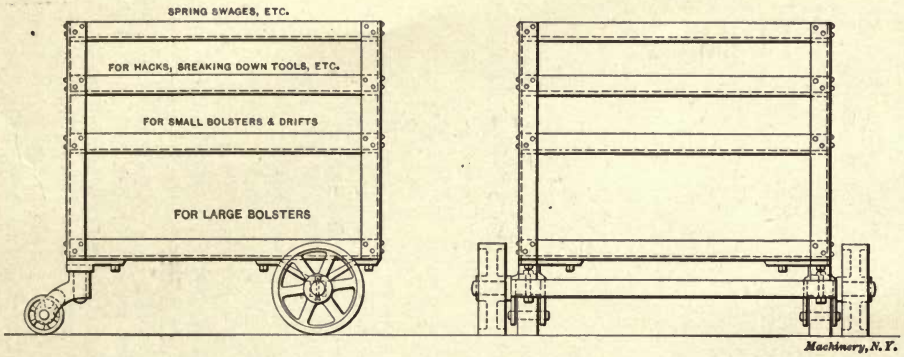


Fig. 1. Portable Rack for Steam Hammer Tools

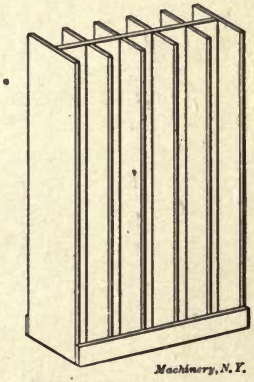


Fig. 2. Upright Rack for Light Bars

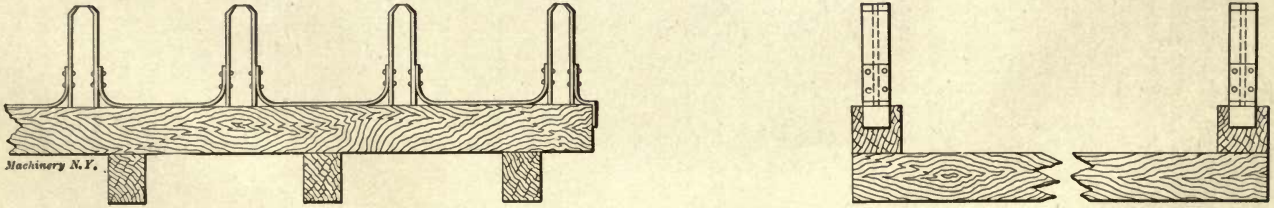


Fig. 3. Rack for Heavy Bars

The spaces assigned to cutting-off machinery, etc., and that for drop-hammers and other machines used in making die forgings has not been laid out in detail for the reason that machines for that class of work vary so much in general outline and in size that it would be difficult to arrange them satisfactorily except by knowing the size of work they are to be used for.

Bar Stock Racks and Storage

In storing bar stock several things have to be considered if time is to be saved and the chances of making mistakes in using wrong material minimized. Racks are necessary for the purpose and should be constructed in a manner best suited for the accommodation of the

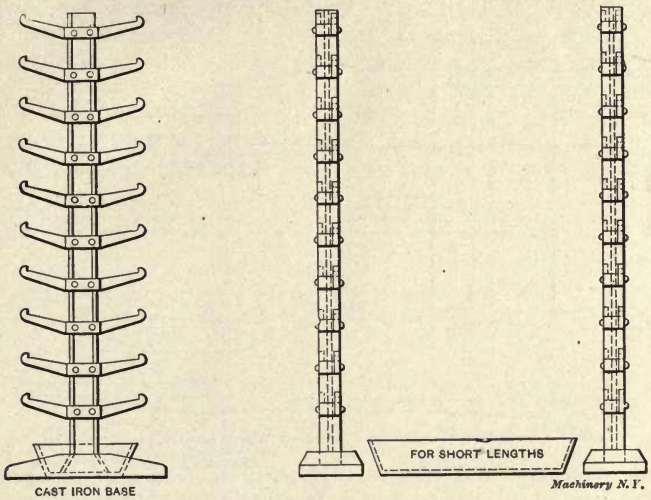


Fig. 4. Rack for Round or Square Bar Stock up to Four Inches

various kinds of material, and so that bars can be lifted from the sides instead of having to be pulled from the end, as must be done when the common lattice pattern rack is used. For tool steel or any other special material, racks of the type shown in Fig. 2 will be found to be the most convenient, as bars can be stood on end irrespective of length, and short pieces kept in the enclosed portion at the bottom. For the more ordinary grades of stock up to a certain size, a rack of the type shown in Figs. 4 and 5 will be found to be very convenient, as bars can be removed from the sides, which is much more expedient than pulling them from the ends. Lengths too short to be supported by the arms can be placed in the box-shaped receptacle at the base. For bars too heavy to be stored upon racks of the types already shown, a platform raised a little above the level of the floor and divided into sections by upright stakes, which may either be of cast iron or steel of structural shapes as shown in Fig. 3, may be used. All material should be designated by colors on the ends of the bars to correspond with the colors of the racks in which they are stored.

Communication between the stock-room and cutting-off department should be through sliding doors that would permit of bars too heavy to be lifted by hand, being lifted and conveyed between the two places by an overhead trolley system, to pass through the sliding doors at the point where they come together.

Fuel Storage and Roof Construction

On the opposite side of the building from the bar stock store are the pockets for storing coal, coke, charcoal or any of the other solid fuels that may be used. The approach to these pockets is a line of standard gage car tracks elevated upon trestle work and entering the building through a door in the end wall above the level of the pockets as shown in the lower view on page 21, this door being large enough

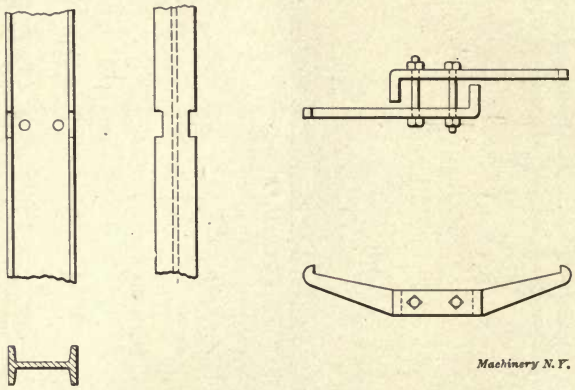


Fig. 5. Detail of Upright and Arms for Rack shown in Fig. 4

to admit locomotive and cars so that coal, etc., could be dumped directly into the pockets from which it could be supplied to forges or furnaces by hand cars.

The roofing of a building as here depicted, apart from general outlines, is a subject upon which the constructing engineer ought to be left with a free hand, as stresses must be calculated and tension and compression members of the trusses arranged accordingly. The sides of the ventilating monitor, however, should be at least 6 feet in height to admit of the windows used being of a size sufficient to throw good light upon the anvils at the opposite sides of the shop. These windows should be balanced upon horizontal trunnions so that they could be opened and closed by means of cords or rods operated from the floor.

CHAPTER II

WELDING*

Up to comparatively recent years, the only process of welding wrought iron and steel was to heat the parts to be welded in a forge or furnace until they had reached a semi-melting condition, after which they were united by hammering. At the present time there are several distinct processes which give the same, or in some cases, better results than are possible by the ordinary process mentioned. Among these may be mentioned the Thermit process (see MACHINERY, March, 1903), the electric welding process (see MACHINERY, April, 1908), and the autogenous welding process (see MACHINERY, October, 1908).

The first mention of welding by electricity, was made by James P. Joule, of Manchester, England, in a paper published in 1856. It was, however, more than thirty years later before electricity became used for welding in the mechanical arts. One feature of importance in re-

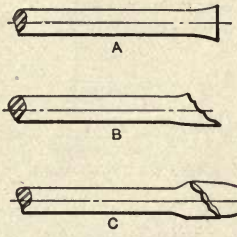


Fig. 6. Incorrect Upset and Scarfing for Plain Lap Welding

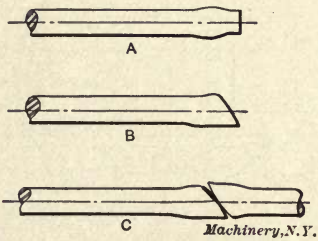


Fig. 7. Correct Upset and Scarfing for Plain Lap Welding

lation to the electric welding is that it makes possible not only the welding of iron and steel, but of metals widely dissimilar, as high carbon to low carbon steel, brass or copper to iron or steel, etc. It is, however, the writer's intention to deal in the following principally with welding as it is, or rather as it should be, done at the forge. It is the oldest, the most common, and, perhaps, the least understood of the welding processes. It has not received the attention that its importance merits, nor has it improved with other mechanical arts. Brawn and muscle have generally been considered more essential to the blacksmith than brains, and thus the fact that preparing the pieces to be welded is of as much importance as the actual heating and hammering, is far too seldom taken into consideration. The preparation of work for welding depends greatly upon the shape of the forging and the class of work for which it is intended.

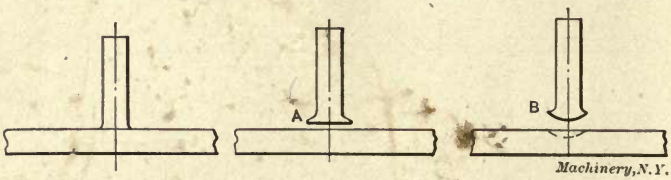
Plain Lap Weld

The most common joint is the plain lap weld used on plain straight work, such as round, square, or flat stock, up to a certain weight and

* MACHINERY, December, 1908.

length. In nine cases out of every ten, the pieces are prepared and placed together for welding as shown in Fig. 6. The upsetting is done on the extreme ends of the pieces, as shown at *A*, and the greater part of the upset has to be drawn down to form a scarf, the face and sides of which are generally a series of steps or notches as indicated at *B*. The parts are placed in position for welding as shown at *C*. Some blacksmiths claim that notches on a scarf are an advantage and keep the pieces from slipping when being hammered together. This idea is responsible for a great deal of poor welding inasmuch as the notches make the best kind of a trap for slag or any foreign matter that is liable to adhere to them while heating. If this slag is closed in between the pieces, as it is almost sure to be when the points of the scarfs are welded first, as is generally done, all means of escape for slag or dirt is cut off, and the welding will only be effected in spots. The defect will show up in machining if the weld does not come apart before.

If pieces are prepared as shown in Fig. 7, defective welding will be reduced to the minimum. The upsetting should be done at least the



Machinery, N.Y.

Fig. 8. Correct and Incorrect Methods of Scarfing for Jump Weld

thickness of the stock from the end, as at *A*, so that it will not be affected by the scarfing. This makes less upsetting necessary, and the scarfing is more easily done. The face and sides of the scarf should be fairly smooth, and crowned slightly in the center as at *B*, so that when they have been heated and brought together for welding, the center will be the first part to unite as shown at *C*. Any slag or dirt that may have adhered to the heated surfaces will be forced out as the welding proceeds from the center to the point of one scarf and then to the other.

Jump Weld

In welding forgings of the style shown in Fig. 8, usually only one piece, the shank, is prepared. It is upset on the extreme end, the edges scarfed and thinned, and the face left perfectly level, as shown at *A*. When prepared in this manner, the chances are that a little slag will adhere to the flat surface and be closed in between the two pieces. The edges of the scarf will be the only parts to unite with the other piece, and will have to support the whole strain that may come on the forging.

Work of this kind should be prepared as shown at *B*, the flat piece being hollowed out with a bob-punch as shown by the dotted line, and the shank upset and scarfed, as indicated, until it is just small enough so that the spherical portion will bear in the bottom of the impression,

but not quite touch the sides. When heated to a welding temperature and placed in position, the first point of adhesion will be at the center, and two or three blows will upset the shank sufficiently to fill the impression. Any slag or dirt will be forced out as the welding proceeds, and a solid piece of work is insured when the weld is completed. This style of welding is known as jump welding.

Butt Weld

Shafting and similar work, when made of wrought iron, can be butt-welded to advantage, the only preparation necessary being to upset the ends coming together, slightly crowning them in the center. The two ends are kept in alignment with a dowel pin as shown in

Fig. 9. Wrought Iron Shaft Prepared for Butt Welding

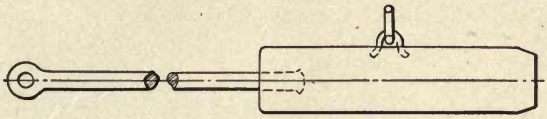


Fig. 10. Ram for Upsetting Long Bars

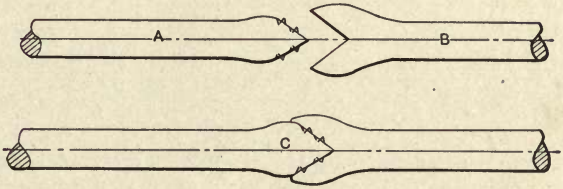


Fig. 11. Steel Shaft Prepared for Welding

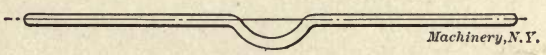


Fig. 12. Carrying-bar for Long Heavy Forgings

Fig. 9. When heated to the proper temperature, the parts may be welded before they are removed from the forge by using a sledge hammer on one end, or, if the pieces are of large dimensions, a ram should be used. The welding commences at the center, and all slag or dirt is forced out as the pieces come together. By the time the weld is complete, the diameter around the heated parts will be found to have increased. This excess can be worked down to the same size as the rest of the piece either at the anvil or steam hammer while it is still at a welding temperature.

Welding Steel

It is not advisable to butt-weld steel at the forge, as the pieces are liable to come apart when the upset portion is being worked down to

the same size as the rest of the piece. All forgings either of ordinary machinery or carbon steel should be made from the solid, if possible. If this is impracticable, welding should be done either by the plain lap method or by split weld. The split weld is seldom used except upon very long or heavy work, such as shafting, lead-screws for long lathes, and similar work where the parts are either too long or too heavy to be heated separately and placed upon each other for welding with any degree of comfort or accuracy. Work of this kind is usually prepared for welding by being heated on the end and upset with a ram of the style shown in Fig. 10, which is suspended from above by a chain attached to the ring of the ram with a hook. The ram is arranged so that it can be adjusted to any height. It is swung horizontally by means of a rope attached to the shank or handle. Three or four men are needed to give it momentum and one man to guide it by the shank. An equal number of men are needed to keep the shaft

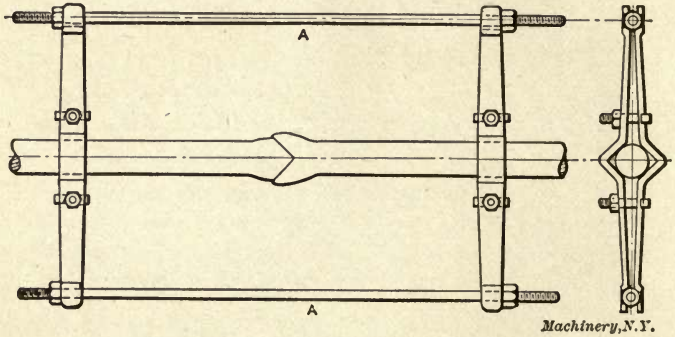


Fig. 13. Heavy Shafting Prepared for Welding

in position when acted upon by the ram. When the pieces have been sufficiently upset, one is scarfed as shown at *A*, Fig. 11, and the other is split and scarfed in the shape of a snake's head as shown at *B*. A few sharp burrs are raised with a chisel on the sides of *A*. Part *B* is heated and closed in on the burrs which keep it in position, as shown at *C*. The parts are then placed on the forge, heated, and welded in the usual manner at the steam hammer.

Bars of the style shown in Fig. 12 are used to lift the shaft from the forge and convey it to the hammer. One man is required for each end of the bar; sometimes as many as a dozen or more bars are used, according to the length and weight of the work. When the diameter exceeds three inches, the separate pieces are usually held in position by means of clamps, as shown in Fig. 13. When the heat has been raised sufficiently high for welding the pieces, they may be forced together, before removing them from the forge, by using a sledge hammer or a ram on one end of the work. When the pieces have been fairly united, the tie rods *A* are removed, allowing the work to be turned in the fire so that all sides can be brought as near as possible to the same temperature. The shaft is then lifted from the forge to the steam hammer, where the welded portion is worked

down to about the same diameter as the remainder, using the clamps which are still left in position for handling and turning it.

Making Long Lead-screws

Lead-screws frequently are as long as sixty feet, and occasionally eighty feet or over. Defective welding on this class of work is very serious as it renders the screws practically useless. When work of this nature exceeds the length of the longest lathe in the shop, two or three bars, together equaling in length about the capacity of the available lathe, are welded together, turned, and the thread cut to within

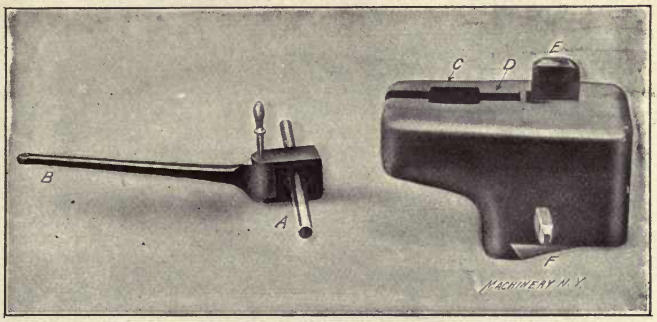


Fig. 14. Upsetting Attachment for Preparing Heavy Shafts for Welding

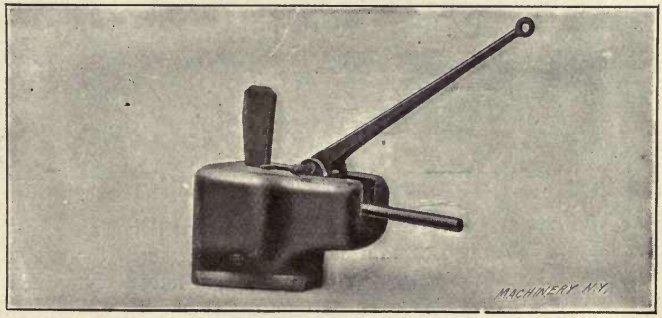


Fig. 15. Upsetting Attachment ready for Operation

about three feet of the end of the bar. This is then returned to the blacksmith shop where a few more lengths are welded on, which are also turned and threaded. This is repeated until the full length has been reached.

To facilitate handling and to reduce the cost of such work, the writer designed the upsetting attachment for the steam hammer shown in Fig. 14, which takes the place of the ram and can be used with considerably less help, the blacksmith, his helper, and the steam hammer operator being all that is required. To use the attachment, the anvil block is removed from the steam hammer, and the fixture is keyed in its place. The ends of the bars to be upset are heated, placed in V-blocks *A*, which are notched or toothed inside to insure their

bearing being firm upon the work, the grip being just behind the heated portion. The V-blocks are brought to bear upon the work by means of a lever and cam *B*. The V-blocks with the work held firmly between them are placed in a recess *C* in the end of the fixture, thereby preventing them from moving backwards. A steel plate made to slide in groove *D* comes in contact with the hot end of the work. The plate is forced forward in the groove by wedge *E*, driven home by the steam hammer. Should the wedge in any way become cramped, it can be removed by a small wedge *F* which crosses its point near the lower side of the attachment. If the amount of upsetting done at one operation is insufficient, the grip can be released upon the work in the

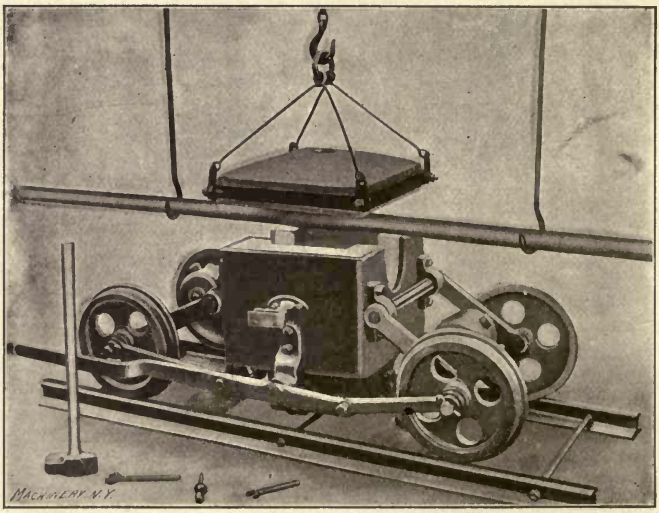


Fig. 16. Portable Forge ready for Use

V-blocks, the shaft pushed through as far as it will go, and the operation repeated. A fixture of this style can be arranged to form collars or in fact any kind of work where upsetting is necessary. In Fig. 15 the device is shown ready for operation.

Portable Forge for Welding

Figs. 16 and 17 show a portable forge specially designed by the writer for heating long work to be welded. The general arrangements are such as to afford greater convenience in heating and handling this class of work than is possible with an ordinary forge. By its use a saving of at least 75 per cent in help is effected. In Fig. 16 the work is shown in position ready for heating, and supported by hooks. The body of the forge is made deep enough to support the sides of the fire which necessarily have to be high enough to allow the work to be covered by it. The forge is lined with fire brick to prevent the sides getting overheated and warped. The top is covered with a large fire brick bound around the edges with iron straps, and supported by a

chain from above. A hole in the center of the brick allows smoke and gases to escape; this hole can be closed or partly closed, when necessary, with a piece of sheet iron or boiler plate. The fire brick cover gives all the advantages and none of the disadvantages of a hollow fire for welding, as it can be placed in position or removed without in the least disturbing the fire. The forge is mounted on wheels attached to the body with axles which can be spread by means of a lever and link motion (see Figs. 16 and 17), allowing the body to drop far enough for work to be removed without lifting it to clear the sides of the fire. To make the forge easy to raise and lower, the body is counterweighted, the weights being made to slide on levers so that they can be adjusted to give a perfect balance. They are held in posi-

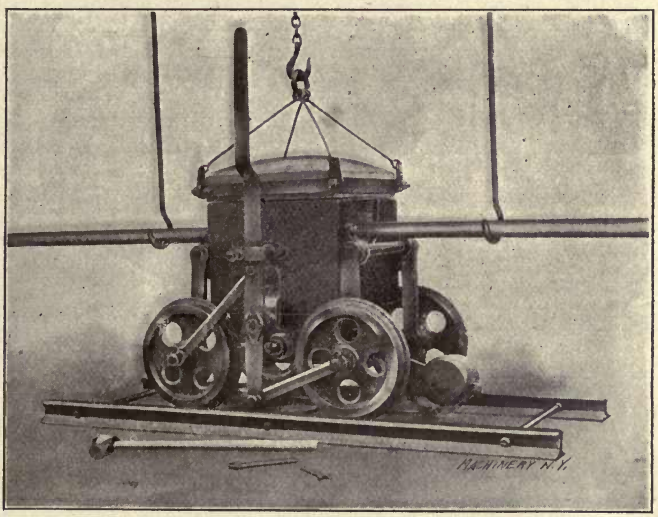
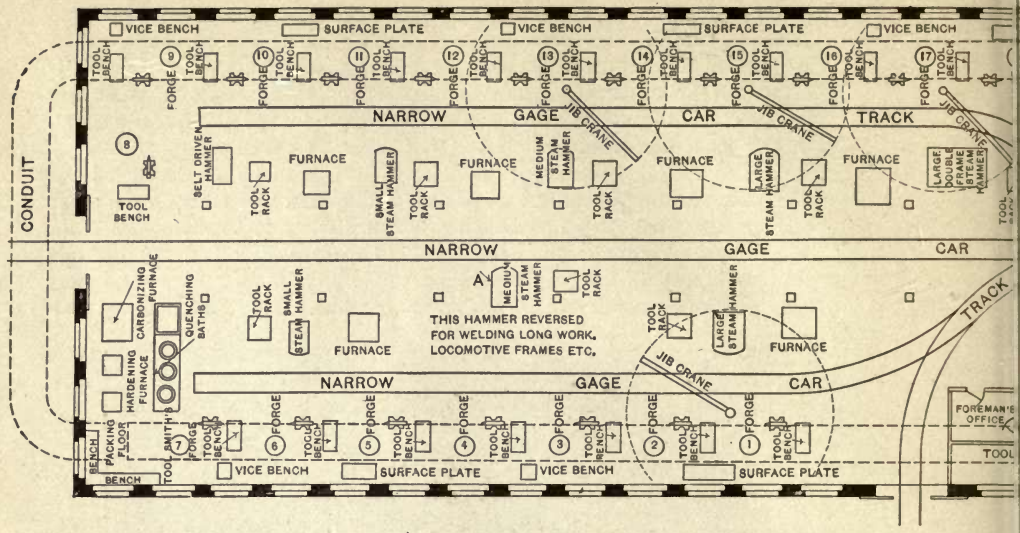
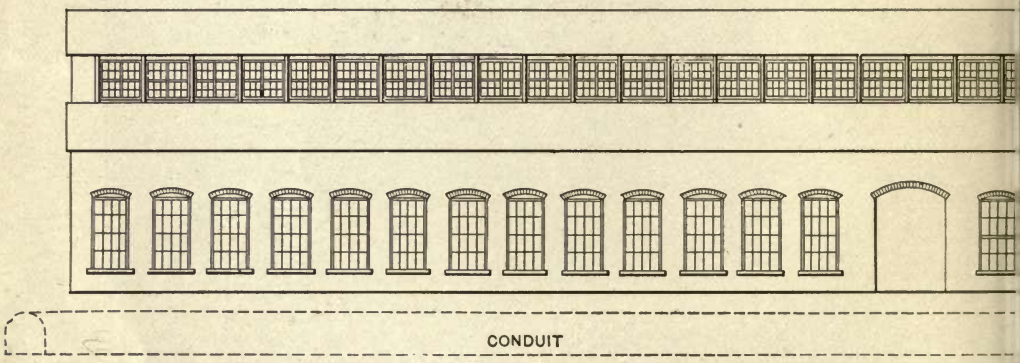


Fig. 17. Portable Forge in Raised Position

tion with set-screws. The other ends of the levers are connected to the body with links, and work in fulcrums attached to the track on which the wheels rest. The fulcrums are just high enough to clear the bottom of the air chamber when the forge is raised to its full height, which allows it to be easily removed from the track when the levers are disconnected. Fig. 16 shows the forge lowered, and the brick cover suspended by the chain clear of the work. The latter can be conveyed to the steam hammer, as it rests in hooks connected with an overhead trolley. Fig. 17 shows a view of the forge when raised to its highest position by the linkage.

Air is supplied from a blower through a flexible hose attached to a flanged pipe. The shut-off can be opened or closed from either side of the forge by means of the two small levers. When in use, the forge has to be placed so that when the work to be welded is in position for heating it will be on the level with the lower die of the steam hammer. It is necessary to use a trolley system of the style indi-





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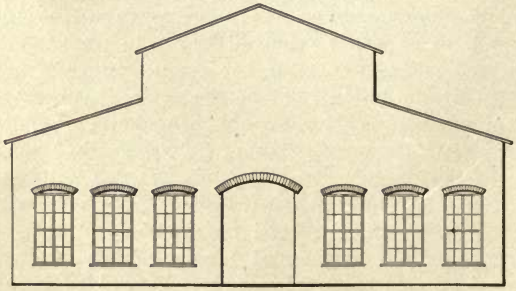
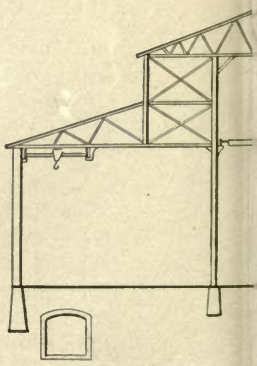


End View of Blacksmith Shop



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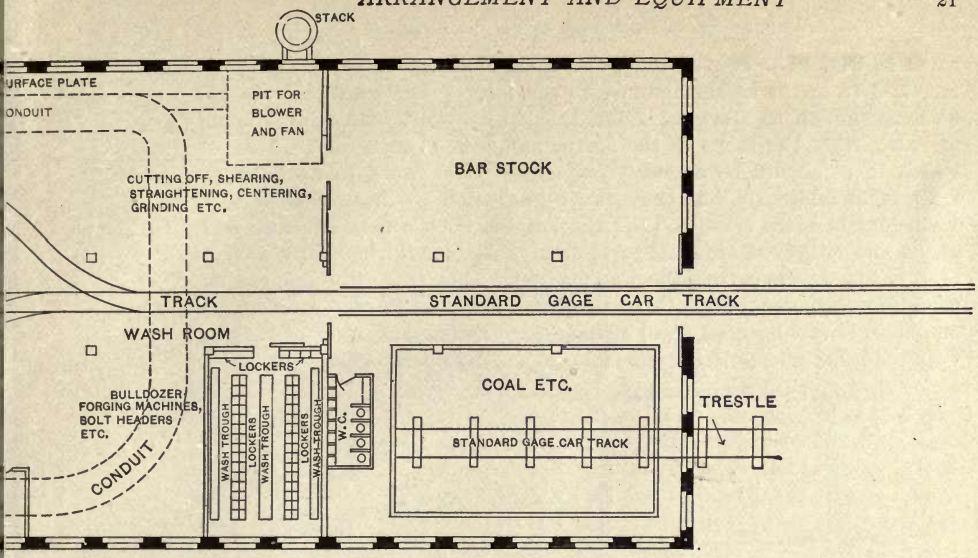

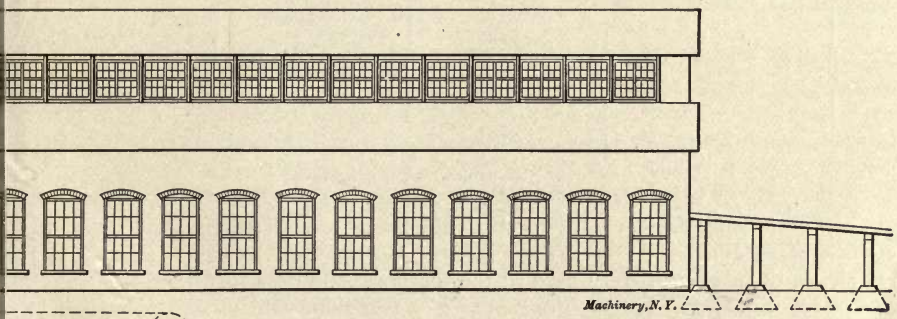

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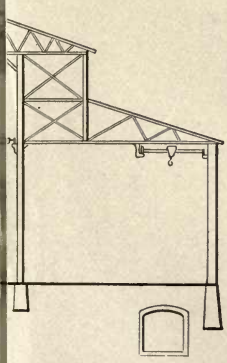
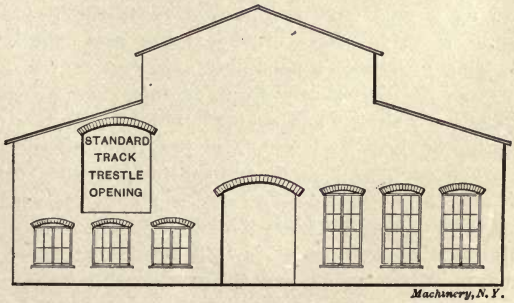


ng Travelers



End View, showing Car Trestle Opening for Discharging Fuel

cated in Fig. 18 to convey the work from the forge to the steam hammer and from the steam hammer to the forge. The side track should be long enough to allow handling the longest work and wide enough to reach from the forge to the steam hammer. The cross trolleys, of which there should be at least four, support the work in hooks fitted with turnbuckles so that they can be adjusted to the proper length. With four or more cross trolleys the longest work can be perfectly balanced and conveyed from forge to steam hammer without any danger of bending or distorting the hot portion. This type of forge can be used for purposes other than welding. By closing the opening on one side, it can be used as a furnace for heating any kind of forging within its capacity. Being portable, it can be placed near a steam or

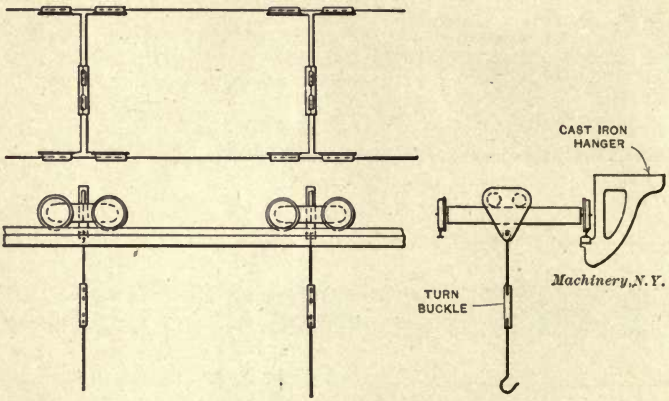


Fig. 18. Diagram of Trolley System in Blacksmith Shop for Handling Long Lead-screws

trip hammer or any other place where it would be most convenient for the work being done.

Fig. 19 shows the style of tuyere used in the forge already described. This type of tuyere can be used with any kind of a forge and will give better results and less trouble than the average tuyere in general use, especially in welding. It being in the shape of half a sphere, clinkers and slag will not choke it but will form a ring around the base and as a rule can be removed from the fire without breaking them up. Most tuyeres in general use are usually flat or slightly hollow. Slag or clinkers accumulate in the center, and are a source of annoyance in doing any kind of forge work, especially welding. The tuyere here shown has a single hole to admit air which tends to concentrate the heat and keep the fire from spreading. No bolts or screws are needed to keep it in position; a little fireclay packed between it and the bottom of the forge is all that is necessary to make it air-tight at the base and keep it in place.

In all kinds of welding it is important that there be a fair depth of fire between the tuyere and the work so that the oxygen in the air will be consumed before it reaches the pieces being heated, otherwise the work will scale and only unite with difficulty if it unites at all.

For any kind of welding, hollow fires should be used when the shape of the work will permit. In no case should the work be allowed to come in contact with the fuel any more than is necessary.

Fluxes for Welding

Wrought iron can be welded in a clean, well-kept fire without necessarily using a flux of any kind except when the work is very thin. Fine, clean sand will answer the purpose. With steel of any kind it is different, as there is no kind of steel that will stand the same amount of heat as wrought iron. A flux of some kind must be used to get the separate pieces in a condition to adhere to each other. There is a large variety of welding compounds on the market; some of them are suited for one class of welding, some of them for other classes. Welding plates or any of the gritty brands are suitable for any kind of welding when the pieces are heated separately. For pieces put together previous to welding, as in split welds, or when taking a second heat, usually termed a "wash," a compound or flux that will flow freely should be used.

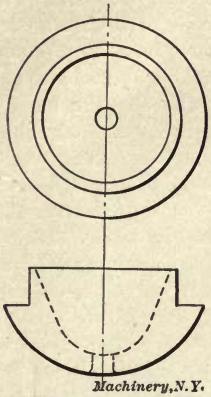


Fig. 19. Tuyere for Portable Forge in Figs. 16 and 17

When borax is used for a flux it will give the best results if burned, which can be done by heating it in a crucible until it has been reduced to a liquid state. It should then be poured on a flat surface to form a sheet. When cold it can easily be broken up and pulverized. The powder can be used as it is, or it can be mixed with an equal quantity of fine, clean sand and about 25 per cent of iron (not steel) filings or small chips.

Too much care or attention cannot be given to welding. Poor welding may mean a railway wreck, a steamship disaster, or a number of other things likely to endanger life and property.

CHAPTER III

THE FORGING OF HOOKS AND CHAINS*

Most of the available information relative to hooks and chains is of a technical nature, and is better suited to meet the needs of the designer and draftsman than the blacksmith. There are given numerous tables of dimensions, and sizes, angles, etc., for finished hooks, but no information or rule seems to have been published whereby the blacksmith may arrive at a definite conclusion as to the diameter and length of material to use for hooks of different capacities. This condition has been responsible not only for a great deal of guess work, but also for the existence of poorly-constructed and very unsatifactory hooks, which generally have required more time and material to make than necessary. When hooks of either of the types shown at *B* and *C*, Fig. 20, are to be forged, stock of the diameter *A* of the hook

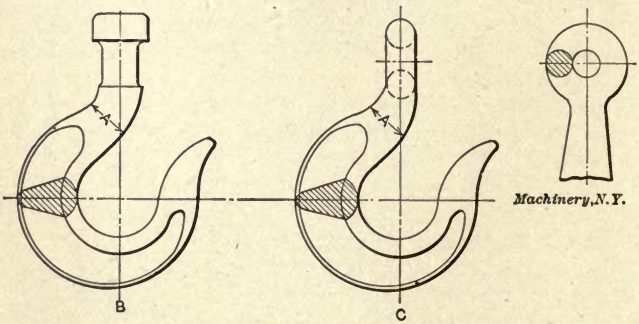


Fig. 20. Two Common Types of Crane Hooks

should be used. If a hook is made in proportion to a chain to which it is to be attached, the easiest and simplest method of determining the right diameter of material to use is to multiply the diameter of the material of which the chain is made by 2½. For obtaining the length of the material for the hook, multiply the diameter by 7. Take for example a chain of standard pattern made from material ½ inch in diameter, which is generally recognized as the correct size for a working load of 1½ ton; then ½ inch × 2½ = 1¼ inch; 1¼ inch × 7 = 8¾ inches; therefore 8¾ inches of material 1¼ inch in diameter is the right amount of stock to use for a hook that will take a working load of 1½ ton. If properly forged, a hook made from this material will be in accordance with the tables of dimensions generally given for crane hooks.

Swivel hooks up to 3000 pounds capacity are made from the end of a bar which ought to be cut the right length to permit the making of a

* MACHINERY, April, 1909.

certain number without waste. The first operation is to taper the end of the bar for the point of the hook as shown in Fig. 21. Where there is a power or steam hammer this is done by means of spring swages made with a taper impression as shown in Fig. 23. A sufficient length of the stock for one hook is then heated and bent to about two-thirds of a circle.† After the hook is bent, it is removed from the bending device and is tapered or "fished" on the back at the same heat, by using tapering tools made on the same principle as spring swages, and shown in Fig. 24. The faces are slightly convex

Fig. 21. Tapering the End of the Bar for the Point of the Hook

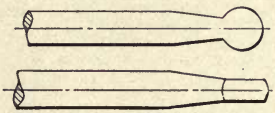


Fig. 22. Tapering and Shaping the Upper End of an Eye Hook

lengthwise, and the edges well rounded off to prevent leaving marks on the work. As the back of the hook is tapered, it is drawn a little on the outside; this closes it sufficiently, so that but very little finishing or truing up by hand is necessary. It is now ready to be separated from the bar. Material for heavier swivel hooks, and all sizes of hooks to be made with eyes, should be cut in lengths that will each make one hook. The reason for this is that swivel hooks over 3000 pounds capacity would be too stiff and heavy to be bent by a hand bending device, and hooks with eyes must be tapered at both the neck and the point.

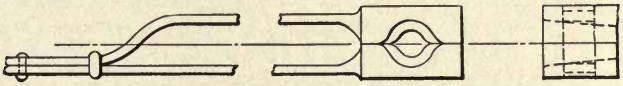


Fig. 23

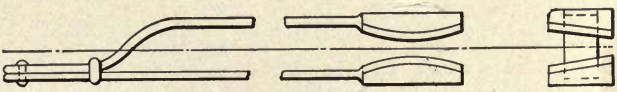


Fig. 24

Figs. 23 and 24. Tools used in Forging Hooks

Eye hooks can be tapered at both neck and point with the same swages as are used for tapering the points of swivel hooks. The first operation in making eye hooks is to taper the neck, after which the portion for the eye should be flattened down to about half the thickness of the material used, and roughly rounded as shown in Fig. 22. The hole for the eye is then punched, the blacksmith removing as little stock as possible and drifting until the hole is large enough to admit of tools of the style shown in Fig. 25 being used to finish the inside to a half circular section. These tools are used in pairs; one

† For this bending, a device may be used similar to, but heavier than, that shown in Figs. 17 and 18, page 17, of MACHINERY'S Reference Series No. 44, "Machine Blacksmithing."

tool is placed upon the lower die of the steam hammer, the eye of the hook fitted over it, and the other tool is inverted and placed on the upper side of the eye. Two or three blows of the hammer practically finishes the inside of the eye.

The outside is finished at the anvil by using another tool of exactly the same shape as that shown in Fig. 25, but provided with a shank to fit the square hole in the anvil. A short swage, the face of which is radial, and having a circular impression well backed off at the edges, as shown in Fig. 26, is used to smooth the outside as the eye rests on the tool in the anvil. When this is done, the point is tapered and the hook is ready for bending, which on the smaller sizes may be done at the anvil without special tools; but large sizes of both

Fig.25

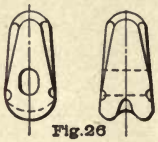


Fig.26

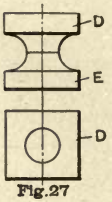


Fig.27

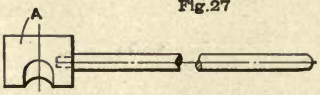


Fig. 28

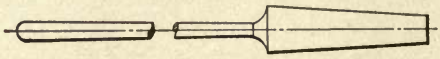


Fig. 29

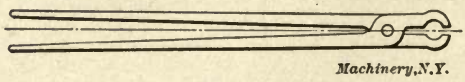


Fig. 30

Figs. 25 to 30. Tools used in Forging Hooks and Chains

types can be more easily and quickly bent at the steam hammer by using the former shown in Fig. 31 to start the bend. The body of the former is of cast iron, with a steel wedge or binder. Hooks to be bent are heated all over; the portion for the shank of swivel hooks is placed between two V-blocks *C* which are made to fit between the lugs of the former, and are held firmly in place by wedge *B*. A steel block *A*, Figs. 28 and 31, the face of which is made on an arc to conform to the radius of the former, and having a circular impression the entire length of the face, is placed on the upper side of the hook, and the bend is started either by gradually admitting steam to the cylinder of the hammer and pressing the hook down as far as the former will admit, or by a series of light blows. The hook is removed from the former, and the bending is continued until the hook is bent to about two-thirds of a circle, by placing it between the dies of the steam hammer as shown in Fig. 32. The back is tapered in the same manner as are smaller sizes, and the inside is trued up on the taper man-

drel, Fig. 29. The advantage of having the mandrel tapered is that it can be used to true up different sizes. Large eye hooks are bent and finished in exactly the same manner except that instead of using V-blocks to hold them on the former, two pieces of steel made to fit the eye of the hook and the lugs of the former as shown at *D* and *E*, Fig. 27, are used.

The Forging of Chains

It is very seldom that chains are forged by the ordinary blacksmith, apart from making a link to repair an old chain, joining two pieces together, or attaching them to hooks or rings. Most of the chains used are made by chain makers who seldom do anything else. They are generally such experts in this kind of work that they can turn out chains in less than half the time it would take the men who only make a link occasionally. Nearly all blacksmiths, however, have to

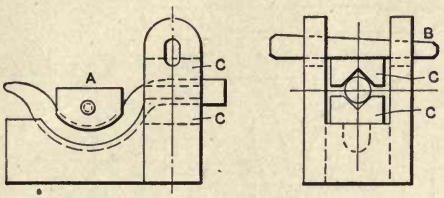


Fig. 31. Device for Starting the Bend in a Crane Hook

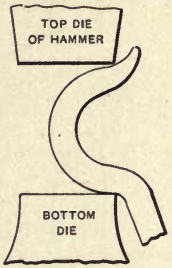


Fig. 32. Completing the Bend of a Hook

do more or less chain repairing, and it is well for them to be posted on this particular class of work. In making chains, the following dimensions will prove satisfactory for general purposes. For notation, refer to Fig. 33.

B = width of link inside = 1¼ A,
C = length of link outside = 5 A,
D = length of link inside = 3 A,
E = width of link outside = 3¼ A.

Large sizes of standard pattern chains are a trifle shorter than the dimensions given above, but for all practical purposes, the formulas given can be followed. The length of chain links inside being only three times the diameter of the material of which they are made makes it rather difficult to join two pieces of chain together with a link the same length as the rest of the chain. As one link of each of the pieces to be joined must be placed inside the connecting link before it can be welded, but very little space is left for holding the connecting link with tongs, and but small room for its being placed on the horn of the anvil for finishing it after the welding. The easiest way to do work of this kind is to bend the link and scarf it as shown at *F*, Fig. 33; then bend the scarfed ends around and close them together as at *G*. After this the link should be heated all over and twisted at the lower end, as shown at *H*, until the scarfed ends

come far enough apart to allow the end links of the pieces to be joined to pass over the ends. The ends are now twisted back to their first position and the link is ready for welding as shown at *K*. The link being already hot, and the end links of the chain cold, it comes to a welding temperature when placed in the fire, before the rest of the chain is affected by the heat. The tongs shown in Fig. 30 are the best kind to use either for chain making or repairing, as they take a good hold upon the work and do not cover enough of it to be in the way.

Chains used in connection with cranes or hoists for lifting heavy pieces are generally made with a hook at one end and a ring at the other; sometimes the chains are single, but quite often two, three or four chains and hooks may be attached to the same ring, according

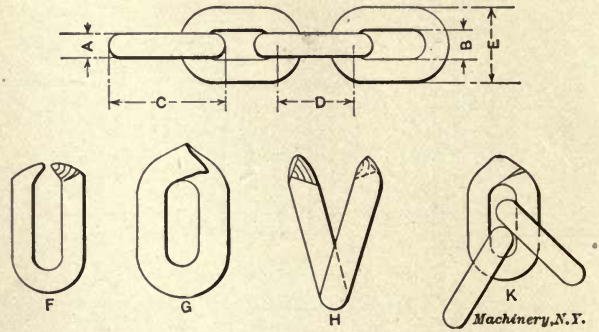


Fig. 33. Notation for Chain Dimensions, and Successive Stages in the Welding of a Chain Link connecting Two Pieces of Chain

to the shape of the pieces they are intended to support. In places where a number of this kind of chains are used it will be found a good plan to give each chain or set of chains a number which should be marked upon them, together with their lifting capacity, in some place where it will be easily seen. A good way to do this is to use a large flat link made from the solid between the ring and the chain as shown in Fig. 34. The holes in the ends are punched and nicely rounded, the same as eyes for hooks. The flat space between the holes is used for the number, working capacity, or any other marks that may be necessary. Lifting chains should be annealed occasionally; by having them numbered or otherwise marked it is easy to keep a record of each chain, when and how it has been repaired, when annealed, etc.

Crane hooks are often used for purposes which make it impossible to get the load in the center of the hook. The point then takes the greater part of the strain, and hooks for such service ought to be made from very heavy bar at least three times the diameter of the chain.

No definite information can be given for the rings, as the size of material to use depends entirely upon the diameter of the ring; the larger the ring the heavier the material should be. It is safest and

best to make rings just as small in diameter as can be conveniently used; the material should in no case be less than one and one-half times the diameter of the chain to which the rings are to be attached. Links used for the purpose of connecting chain and hook should be made as short as possible, from material slightly heavier than that of which the chain is made; 9/16 inch is about right for ½-inch chains, larger and smaller chains to have the links for attaching the hooks or rings in corresponding proportion.

Anyone who has ever attached hooks or rings to chains knows what awkward work it is, especially if the chains are of heavy dimensions; either the hook will come in the way when welding the link next to it, or the chain will keep moving around the sides of the ring. This difficulty can be overcome to a certain extent when attaching hooks by placing the link used for the purpose in the eye of the hook, and driving a wedge behind it as shown in Fig. 35. This holds the link

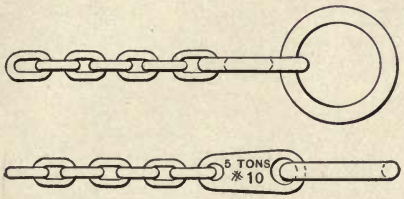
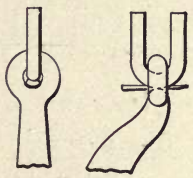


Fig. 34. Marking Chains on Special Marking Link



Machinery N.Y.

Fig. 35. A Kink when Welding Link connecting Hook and Chain

firmly in position while the hook is held in tongs. In attaching chains to a ring, when plain links are used for the purpose, these should be left open enough at one end for the ring. Rings should be prepared for welding in the same manner as shown at *F*, *G*, *H*, and *K*, Fig. 33. In cases where more than one chain is to be connected with one ring, the different pieces of chain should be bound together with wire to prevent their moving around the sides of the ring while it is being heated and welded.

In repairing old and worn chains, material heavier than the original size of the chain should never be used, as the new link then will act as a wedge, and will put a breaking strain on the link. It is always preferable to repair with material the same size as the chain, or, where the links are very much worn, material slightly smaller than the chain will give better satisfaction, as it will readily find a bearing in the worn ends of the links without bringing any additional strain upon them. The new links will be just as strong as the rest of the chain. It is by no means uncommon to see chains that have been repaired with links here and there throughout their length of material considerably heavier than the original size of the chain, which is a mistaken idea of making a strong job, for "chains are never stronger than their weakest link."

The best material to use for chains, hooks and rings is a good grade of wrought iron, such as Swedish or Lowmoor iron, either of

which is freer from silicon, phosphorus, sulphur, or other impurities than the more common brands. The tensile strength of the best grades of wrought iron does not exceed 23 tons to the square inch, while mild steel of about 0.15 per cent carbon will have a tensile strength nearly double this; but the ductility and toughness of wrought iron, which is greater than that of any grade of steel, is in its favor for making appliances that are to be subjected to heavy strains and loads, as it will always give warning by bending or stretching before it fractures or snaps off.

CHAPTER IV

MISCELLANEOUS BLACKSMITH SHOP APPLIANCES AND METHODS

In the present chapter a number of useful blacksmith shop appliances and methods are illustrated and described. The appliances shown have been used by practical blacksmiths in various shops in the country, and the methods described are endorsed by their experience.

A Cheap Home-made Forge*

To make a cheap forge, a cylinder is first made about 3 feet 6 inches in diameter and about 2 feet 9 inches high, from ⅛-inch sheet steel, as shown in Fig. 36. Then two holes are cut in this cylinder opposite each other about 9 inches from the top edge. These holes

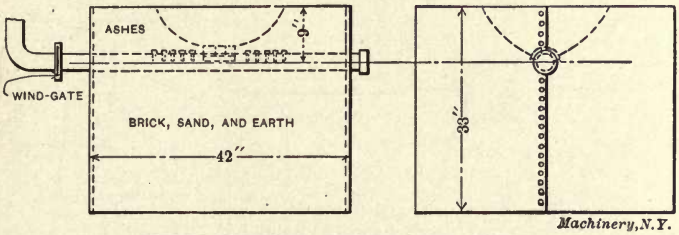


Fig. 36. Serviceable and Inexpensive Forge

should be large enough to allow a 2½- or 3-inch common steam pipe to pass through freely. For a forge intended for heavy forging, a 3-inch pipe is to be preferred. The pipe should be long enough to pass through the cylinder and extend about 2 inches outside on one side, and 6 or 8 inches on the other side of the cylinder. The end of the pipe that extends out about 2 inches should be threaded, and a cap should be screwed on this end in such a way that it can be removed or put on by hand. A wind gate is now put on the other end of the pipe, and this is then attached to the blast pipe. After having laid the pipe in place temporarily, a 1¾-inch hole is drilled into the pipe on one side, and on each side of this hole three ¾-inch holes, followed by two ⅝-inch holes, about 3 inches apart, are drilled. A piece of steel, one inch thick, about 4 or 5 inches wide, and long enough so that it will go at least one-third around the pipe, is now made. In the center of this piece a 1¾-inch hole is drilled, and the piece is bent so that it will fit tne outside of the pipe. This piece is placed directly over the 1¾-inch hole in the pipe, being attached with some fire clay. It serves the purpose of prolonging the life of the

* Geo. T. Coles, MACHINERY, October, 1908.

pipe and keeps the pipe from burning out at the hole. After the forge constructed in this manner is leveled up, broken brick, sand, dirt and cinders are dumped in and packed firmly up to the lower side of the pipe. One-half inch bolts or rivets, about 1½ inch long, are put in the small holes, and then the remaining part of the cylinder is filled up with cinders and packed firmly, space being left to form a pit for the fire. The forge is now ready for use.

The advantages of this forge are: It is possible to make a large or small fire, according to the requirements; if a long fire is required one can pick out enough of the cinders and take out the bolts or rivets mentioned; the length of the fire can be adjusted to the requirements by taking out more or less bolts; there is no brick or fire clay lining to be set before the forge can be used. The writer has

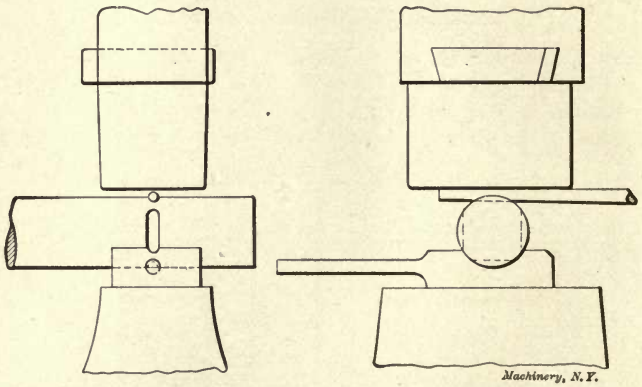


Fig. 37. First Operation in reducing the Diameter of a Tool Steel Bar under the Steam Hammer

built several of these forges in various shops, and they give the best of satisfaction. The forge will work well until the pipe rusts out, and then another pipe is made and put in place at very small expense, and very little loss of time.

When the fire gets dirty, use the poker and poke the dirt down through the hole. Take off the cap at the end of the pipe and open the wind gate and blow out the cinders inside of the pipe. It takes no more than two minutes to clean a fire in one of these forges. The writer prefers this forge to any other as the most serviceable and inexpensive one to use on any class of work. It is adapted to a great variety of forging. The writer has made big blanking dies, welded 8-inch diameter shafts, and put ¼-inch links in chains, on the same forge.

Reducing the Diameter of Tool Steel under the Steam Hammer*

It is often necessary to reduce the diameter of a piece of tool steel from its original size to perhaps one-half that diameter. This is very common in the making of taps and reamers of large diameters,

* Geo. T. Coles, MACHINERY, January, 1908.

where it is wanted to have the shank of considerable smaller diameter than the main part of the tool itself. It is evident that it is a great deal cheaper to forge down the diameter of the shank in such cases, than to use solid stock of the full diameter of the tool, and reduce it by turning, but it is necessary that the work of reducing the diameter under the steam hammer is done in the proper manner. Many blacksmiths do not seem to know how this work should be properly accomplished. The writer has seen many of them take a bar of steel, put it into the fire, leaving it there until the bottom side had arrived at a red-heat, and then turn it and leave it in the fire until the other side got heated, paying no attention to the uniformity of the heat of the piece. The work is then taken to the steam hammer and reduced by continually rolling it around on the sides until

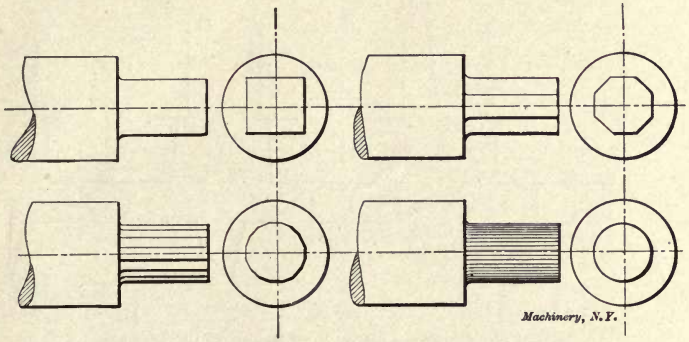


Fig. 38. Successive Steps in reducing the Diameter of a Round Bar

it is reduced to the size wanted. The result of this procedure is always a forging with a spongy or "piped" center. When this sponginess is finally detected in the tool, the steel is blamed as being poor, but as a matter of fact, in most cases, the steel has been satisfactory to start with, and the fault is to be found in improper treatment in the blacksmith shop.

The proper way to reduce the diameter of a piece of tool steel is to first heat it uniformly, and then place it in the steam hammer as shown in Fig. 37. The blacksmith then proceeds to mark the bar on all four sides with a ¾-inch round machine steel bar, long enough to hold in the hand. This marking is intended to give a guidance as to the amount of reduction necessary. When the four sides have been marked as in Fig. 37, then proceed to mark the four corners in the same manner. The piece is turned around from one side to the one diametrically opposite, receiving a blow each time, until a groove all around the piece is made to the proper depth. Then the diameter is reduced by hammering first on one side, and then on the opposite side of the piece, until a square of the size wanted is produced, as shown in Fig. 39. Then the four corners are hammered in a uniform manner until the piece gets an octagon shape, as in Fig. 40. Next the eight corners of the octagon are hammered down, making sixteen

sides, always making sure that the next corner hammered down is diametrically opposite the one just operated upon. Finally, if a swage of the proper size is on hand, the piece can be rounded with this; otherwise when all the corners have been reduced so that they are hardly visible, it is possible to round the piece nicely with even hammer blows until the correct size is arrived at. In Fig. 38 are shown the consecutive shapes assumed by a piece of steel worked down in the manner described.

It is evident that by rounding continually after the first blow is struck, the blow, as shown in Fig. 41, is not directed on a point that has a firm support directly under it, and a kind of twisting action takes place, causing one-half of the bar to have a tendency to slide in relation to the other half of the bar, the result being that the center of the bar is spoiled, and a spongy or, perhaps, a piped center results.

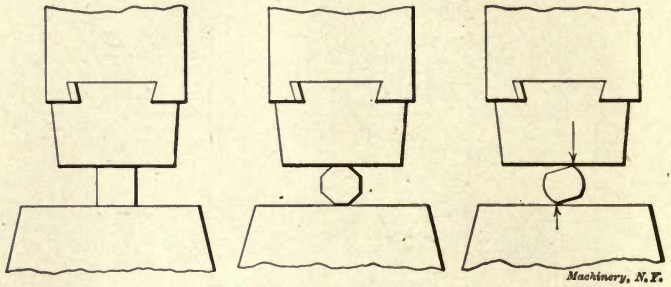


Fig. 39 Fig. 40 Fig. 41

Correct and Incorrect Methods of Reducing the Diameter

In some cases this hollow or piped center is of no consequence, as, for instance, when a hole is later to be drilled through the piece, removing the metal at the center, but it is evident that all efforts should be directed to avoid results of this kind.

Making Collars under the Steam Hammer*

Fig. 42 illustrates a method of making collars under the steam hammer. A large number of collars of different sizes were to be made, and it was necessary that these collars should be made cheaply. The practice had been to buy drop forgings for these collars, but by the method explained below they were made much more cheaply. The material used consisted of scrapped ends of round machine steel bars in various sizes from 2 to 4 inches in diameter. A set of dies of different sizes from 1½ to 4½ inches inside diameter were made, making the holes tapered as shown in the illustration. Then a lot of short punches were made to correspond to these dies, but were made ⅛ inch smaller in diameter than the holes in the dies. None of the punches was longer than 2 inches, and some of them were not longer than 1¼ inch. These were also made tapered as shown. After ascertaining the amount of material needed for a certain size of collar, three, four or five blanks were cut off from a piece of shafting at

* Geo. T. Coles, MACHINERY, June, 1907.

one neat. The pieces were then thrown back into the fire and one at a time taken to the steam hammer, hammering them down until they were of about the right thickness, preferably a little thicker than the size called for. They were then rounded up and flattened again, and the die placed in the steam hammer with the heated blank on it and the punch on top as shown in the illustration, and with one or two moderately hard blows of the hammer, the punch was driven through very easily and the collar was forged. For varying the size of the holes in the collars to be made, taper pins of crucible tool steel were made to drive into the holes after they had been punched.

The plan was so successful that after the scrap steel had been used up, regular bar stock was used for making the collars. The punch-

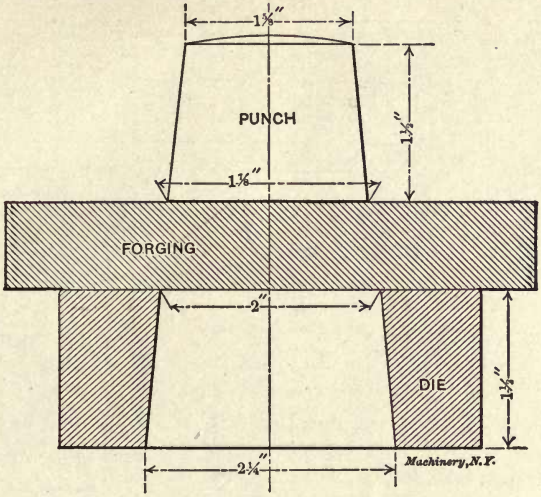


Fig. 42. Punch and Die for Making Collars

ings from the larger collars were used for making the smaller ones, so that there was very little waste; in fact, the waste was less than 15 per cent.

If the punch should happen to shear the die at any time, the blacksmith can work the die over in a few minutes by closing it up and then driving the punch in until the hole is again of the right size. It is not necessary to have sharp edges on the die and punch, but it is necessary to have the bottom and top of the punch as nearly parallel as possible, to prevent the hammer from driving the punch to one side. Care should be taken that the punch is central on the blank before the hammer is applied, so that shearing the die will be avoided. Over 700 collars can be punched with one die without any trouble.

Forging an Eye-bolt*

The writer once had occasion to make some 1¾-inch eye-bolts, that is, eye-bolts having 1¾-inch shank, for generators, and with the tools

* Geo. T. Coles, MACHINERY, September, 1908.

at hand he found it a rather difficult job. In the first place a 2- by 4-inch machine steel bar was hammered down enough for a shank about 2 inches in diameter. The piece was then cut off about 4 inches from the shoulder, and a 2-inch hole punched in the center, which hole was thereafter increased to 3 inches. The corners were then cut off, as shown at *B* in Fig. 44, and the inside and outside corners around the hole were removed in order to procure a circular section at this place. The result was a fairly good-looking job, but the time it required to make the forging was too great, it having required about three hours to make the first eye-bolt, and when the time was cut to 2½ hours, it was considered as doing well.

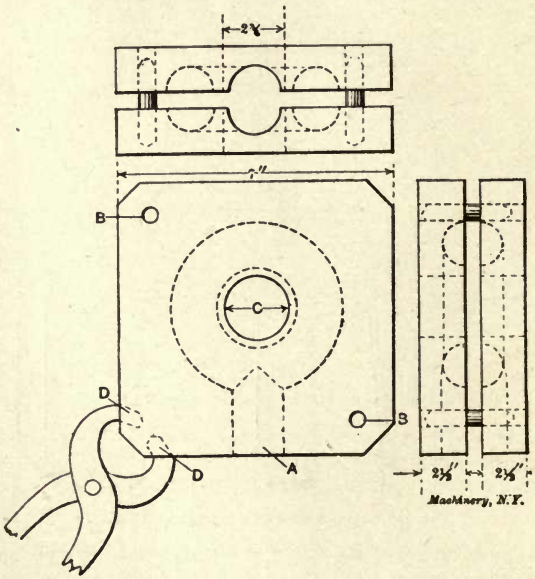


Fig. 43. Former or Die for Eye-bolt Forging

The writer, however, was not satisfied, and when receiving an order for as many as 12 eye-bolts, he undertook to make a forming tool. The tool was made, and the time was cut to three-quarters of of an hour on each eye-bolt, and by using the furnace, they could be made in one-half hour each. It took the writer and a helper about five hours to make the forming tool, and there was four hours machine work on it, making a total of nine hours, or a total cost, including shop cost, of about $11.00. Considering the cost of the first eye-bolt to be in the neighborhood of $4.00, including the shop cost, the saving in time quickly paid for the tool. In the following is described how the tool was made.

One of the best of the eye-bolts previously made was filed up smooth and well rounded for the purpose of forming the tool. A ring was also made of 1¼-inch round machine steel, 3¼ inches inside diameter, as

shown at *A*, Fig. 44, intended for making the first indention in the tool. After this, two pieces of locomotive driving axles were obtained, and two pieces or plates made, 7 inches square by 2½ inches thick. The corners of these were hammered, as shown in Fig. 43. The two pieces were heated, and the ring placed between them, and then hammered together. After this, a piece of 1½-inch round steel was used for forming the groove for the shank as shown at *A*, in Fig. 43. The plates were then again heated, and after having removed the scale, the eye-bolt was put in place between them, and once again the plates were hammered together, after which the edges were worked up with a bob-punch to get them sharp. Then the eye-bolt was put between the plates again for the final blow.

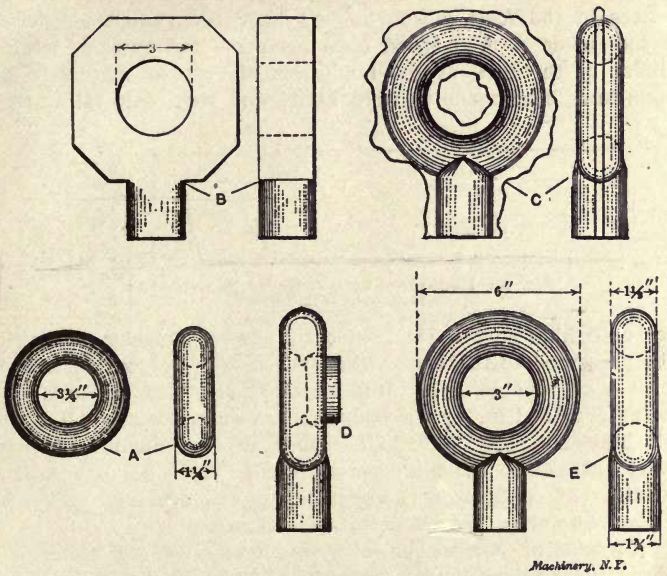


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Fig. 44. Successive Steps in Forging an Eye-bolt

When the steel plates had cooled off, two holes were drilled at opposite corners, as shown at *B* in Fig. 43, while the eye-bolt still remained in place. The plates were then bolted together, and a hole drilled through the center, as shown at *C* in Fig. 43. This hole was bored out to 2¾ inches diameter. The bolts were then taken out, and the holes at the corners drilled for ⅞-inch pins, which were then driven into the bottom part, with the ends tapered slightly on the outer end, so as to enter the holes in the upper part of the tool. The pins were of such length that when the dies were placed together, the pins were below the surface of the dies. Finally holes were drilled in one corner of the upper die at *D*, Fig. 43, to fit the jaws of the tongs for handling it.

The blank forgings may now be made in the same way as before, and as shown at *B* in Fig. 44. The blanks are placed between the form-

ing dies, and these are hammered together, and when the eye-bolt is taken out, the surplus metal will be found around the outside of the eye-bolt and in the hole, as shown at *C*, in Fig. 44. This fin is cut off from the outside, and the eye-bolt is then again heated and placed in the die for a final blow. Then a short piece of steel, 3 inches in diameter and about 1½ inch long, as shown at *D*, Fig. 44, is placed on the die of the steam hammer, and a light blow will clean out the inside edge of the eye-bolt, leaving it finished as shown at *E*, in Fig. 44, excepting for cutting the shank to the proper length.

Welding a High-speed Steel Cutter to a Machine Steel Body*

On account of the high price of high-speed steel, its use, particularly for heavy tools, has been rather limited in the past. All kinds of devices in the form of tool-holders have been adopted whereby a small tool made of high-speed steel performs the cutting, while the remainder of the tool, or the holder, is of cheaper material. Many attempts have been made to weld high-speed steel onto mild steel, as

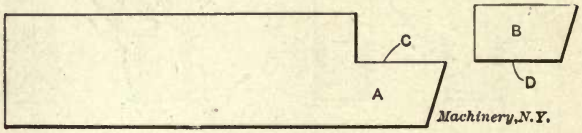

Fig. 45. High-speed Steel Cutter to be welded to Shank of Machine Steel

well as onto high carbon steel, in order that a superior cutting edge may be presented to the work, while the cost of the tool is still kept down to a reasonable figure, the required size and stiffness of the tool being provided for by the body of cheaper material. All attempts to weld high-speed steel onto high carbon steel or machine steel have, however, until quite recently, proved futile. This is apparently due to the different coefficients of expansion of the different steels, high-speed steel having a low coefficient of expansion.

Lately a welding process, however, has been invented which is controlled by the Fusion Welded Metals Co., Ltd., 56 Victoria St., Westminster, London, by means of which it is possible to weld high-speed steel onto other steels. The operations are very simple. The welding of the two steels is performed by means of a thin film of copper. The copper is placed in the form of a feeder along the line of the joint. The parts to be welded are then surrounded by a reducing compound and are placed in a furnace where the temperature is raised to about 2200 degrees F. The gas which is formed by the burning of the compound seems to affect the copper in such a way that the latter is reduced to a fluid as thin as spirits of wine, and in this condition it penetrates the molecular surfaces of the two classes of steel and produces actual cohesion and not merely adhesion. In fact, the weld becomes stronger than the remainder of the metal, so that if the two pieces being welded are forced apart, the line of frac-

* MACHINERY, September, 1908, and May, 1909.

ture will follow the course of a new break rather than pass through the joint. The weld is so close that in some cases it is hardly possible to find a trace of the copper. A wide field of usefulness is predicted for this process. One application which has already been suggested, and where the process most likely will be most commonly used, is that of welding high-speed steel to carbon or machine steel bodies for the production of high-speed cutting tools at a moderate price.

Another method for welding high-speed steel cutters to machine steel bodies or shanks was patented lately by Mr. Paul A. Viallon, 102 Avenue Parmentier, Paris, France. The process, is comparatively simple and inexpensive, and if it should prove successful, would

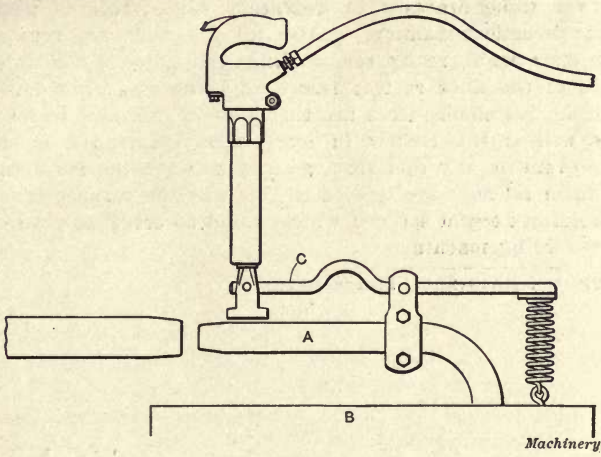

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Fig. 46. Inexpensive Tool for Flue Welding

undoubtedly be valuable in the metal trades. The machine steel shank is indented about as shown at *A* in Fig. 45, and the high-speed steel cutter may have the appearance shown at *B*. The surfaces *C* and *D* are well finished, and the shank and the cutter are both heated to a cherry-red heat. Solder is applied on the surface *C*, the cutter is placed on it, and the two parts are forced together by heavy pressure. This operation has the effect of melting the soldering material and producing adherence between the cutter and the shank. The tool is now carefully put into the fire, from where it is withdrawn when it has reached a yellow heat (2000 to 2400 degrees F.). The weld is now completed by hammering at the top of the tool, first lightly, and then with heavier blows. The tool is permitted to cool slowly, and may then be dressed and finished and re-heated to the required hardening temperature for high-speed steel, and hardened. When the welded-on part of high-speed steel is worn down so that it must be replaced by a new cutter, the old cutter may be detached without injuring the machine steel shank, by heating the cutter

and the shank at the joint, and then removing the cutter by pressure applied on its side.

Pneumatic Flue Welder*

An inexpensive flue-welding device designed to handle large repair jobs is shown in Fig. 46. It consists of a mandrel *A*, which is attached to a cast-iron block *B*, and a pneumatic hammer (equipped with a swage), which is mounted on a lever *C*. As the illustration shows, this arm is fulcrumed to a bracket on the mandrel and is spring supported. The ends of the long pieces are first scarfed by lowering the back end of the tube until it is about six inches below the level of the mandrel. This gives a taper of approximately ¼ inch to the inch. After all the long pieces are scarfed, short pieces about 8 inches long are placed in the furnace and heated on one end so that they can be drawn to a feather edge. This is also done under the pneumatic hammer. After all the flues are scarfed and the short ends made ready for welding, the horse upon which the outer ends of the flues rest is raised to bring the work level with the mandrel. All short pieces are then put on the flues while hot so that they will shrink tightly in place, thus insuring a good clean weld by preventing any dirt from getting between the surfaces to be welded. After all flues are treated in this way the furnace is cleaned, and the welding done at a speed which would do credit to many of the costly flue-welding machines.

* T. O. Martin, MACHINERY, February, 1910.

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